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EXAMINER

MUTSCHLER, BRIAN L

ART UNIT	PAPER NUMBER
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1753

DATE MAILED: 04/02/2004

Please find below and/or attached an Office communication concerning this application or proceeding.

**Office Action Summary**

Application No.

09/929,213

Applicant(s)

CHIKARMANE ET AL.

Examiner

Brian L. Mutschler

Art Unit

1753

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

**Period for Reply**

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

**Status**

- 1) ☐ Responsive to communication(s) filed on \_\_\_\_.
- 2a) ☐ This action is **FINAL**. 2b) ☒ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

**Disposition of Claims**

- 4) ☒ Claim(s) 1-30 is/are pending in the application.
- 4a) Of the above claim(s) \_\_\_\_ is/are withdrawn from consideration.
- 5) ☐ Claim(s) \_\_\_\_ is/are allowed.
- 6) ☒ Claim(s) 1-30 is/are rejected.
- 7) ☐ Claim(s) \_\_\_\_ is/are objected to.
- 8) ☐ Claim(s) \_\_\_\_ are subject to restriction and/or election requirement.

**Application Papers**

- 9) ☒ The specification is objected to by the Examiner.
- 10) ☒ The drawing(s) filed on 14 August 2001 is/are: a) ☒ accepted or b) ☐ objected to by the Examiner.  
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).  
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

**Priority under 35 U.S.C. § 119**

- 12) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☐ All b) ☐ Some \* c) ☐ None of:
- ☐ Certified copies of the priority documents have been received.
  - ☐ Certified copies of the priority documents have been received in Application No. \_\_\_\_.
  - ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

\* See the attached detailed Office action for a list of the certified copies not received.

**Attachment(s)**

- 1) ☒ Notice of References Cited (PTO-892)
- 2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
- 3) ☒ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08)  
Paper No(s)/Mail Date 20010814, 20030602.
- 4) ☐ Interview Summary (PTO-413)  
Paper No(s)/Mail Date. \_\_\_\_.
- 5) ☐ Notice of Informal Patent Application (PTO-152)
- 6) ☐ Other: \_\_\_\_.

## **DETAILED ACTION**

### ***Specification***

1. The abstract of the disclosure is objected to because it contains more than one paragraph. Correction is required. See MPEP § 608.01(b).
2. Applicant is reminded of the proper language and format for an abstract of the disclosure.

The abstract should be in narrative form and generally limited to a single paragraph on a separate sheet within the range of 50 to 150 words. It is important that the abstract not exceed 150 words in length since the space provided for the abstract on the computer tape used by the printer is limited. The form and legal phraseology often used in patent claims, such as "means" and "said," should be avoided. The abstract should describe the disclosure sufficiently to assist readers in deciding whether there is a need for consulting the full patent text for details.

The language should be clear and concise and should not repeat information given in the title. It should avoid using phrases which can be implied, such as, "The disclosure concerns," "The disclosure defined by this invention," "The disclosure describes," etc.

### ***Claim Rejections - 35 USC § 112***

3. The following is a quotation of the first paragraph of 35 U.S.C. 112:

The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same and shall set forth the best mode contemplated by the inventor of carrying out his invention.

4. Claims 2-4 are rejected under 35 U.S.C. 112, first paragraph, because the specification, while being enabling for performing an in situ surface treatment to form a passivation layer using oxygen gas, does not reasonably provide enablement for in situ surface treatment performed in a gas environment selected from the group consisting of inert gases, hydrogen gas, fluorine containing gas, forming gas, and nitrogen gas, or for in situ surface treatment performed using a liquid selected from the group consisting of

acids, bases, solvents and de-ionized water. The specification does not enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to use the invention commensurate in scope with these claims.

The disclosure only appears to provide enablement for in situ treatment using an oxygen gas environment to form a passivation layer (see paragraph [0028]). While the disclosure does suggest that the other gases or liquids may be used, there is no support for what those treatments comprise. The in situ surface treatment of claim 1 is the formation of a passivation layer. However, it is not clear whether the in situ surface treatment recited in claims 2-4 is the same in situ surface treatment. If the in situ surface treatment is the same treatment, the disclosure does not provide an enabling disclosure for how the listed gases and liquids can form a passivation layer, especially with regard to inert gases and hydrogen, which is a reducing gas that performs the opposite of the oxidizing passivation disclosed. If the treatments are different treatments, the disclosure fails to disclose what the treatment comprises, the purpose of the treatment, or the result of the treatment. For example, how an inert gas treats a surface is unclear. Moreover, what surface is treated? Possible surfaces include the substrate structure, the barrier layer, and the metal seed layer.

The claims and the disclosure are enabling for an in situ surface treatment comprising the passivation of the seed layer, such as the oxidation of a copper seed layer in an oxygen gas environment.

5. The following is a quotation of the second paragraph of 35 U.S.C. 112:

The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

6. Claims 1-27, and 30 are rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

Claim 1 is indefinite because the relationship between the step of providing a substrate structure into a chamber of a first tool and the remaining steps is unclear. Are all of the methods, i.e., forming the barrier and seed layer and the in situ surface treatment to form a passivation layer, performed in the chamber of the first tool? As claimed, the formation of the barrier, seed, and passivation layers can occur outside of the chamber and outside of the tool. The same applies to dependent claims 2-21.

Claims 2-4 recite the limitation "wherein in situ surface treatment is performed" in line 1 of each claim. This limitation is indefinite because it is unclear whether the in situ surface treatment is the same as the in situ surface treatment recited in claim 1.

Claim 8 is indefinite because the relationship between the method steps is unclear. What is the relationship between the filling of the chamber with gas and the formation of the passivation layer? Is the gas present during the cooling of the substrate? Does the step of cooling the substrate structure occur in the chamber of the first tool? As claimed, it appears that the step of cooling forms the passivation layer. How is a passivation layer formed simply by cooling the substrate? Additionally, claim 8 is indefinite because it is not clear if the passivation layer formed in line 6 is the same passivation layer formed in claim 1. The same applies to dependent claims 9-12.

Claim 15 recites the limitation “the anneal chamber” in line 2. There is insufficient antecedent basis for this limitation in the claim. The same applies to dependent claims 16-18.

Claim 15 recites the limitation “a third specified period of time” in line 2. This limitation is indefinite because the limitation implies first and second periods of time, which are not present in claims from which claim 15 depends. Similar limitations appear in claim 16 (fourth period of time), claim 17, and claim 18.

Claim 20 recites the limitation “a plating method selected from the group of electrolytic plating and electroless plating” in lines 2-3. This limitation is indefinite because the relationship between a step of electroless plating and an electroplating tool recited in claim 13, from which claim 20 depends. Since there are no other steps of electroplating, the purpose of the electroplating tool is unclear. The same applies to dependent claim 21.

Claim 22 recites the limitation “a plating process selected from the group consisting of electrolytic plating and electroless plating” in lines 8-9. This limitation is indefinite because the relationship between the electroplating tool recited in line 2 and the process of electroless plating is unclear. The same applies to dependent claims 23-27.

Claim 23 recites the limitation “a third specified period of time” in lines 2-3. This limitation is indefinite because it implies first and second periods of time, which are not claimed. Similar limitations are recited in claims 25-27.

Claim 30 recites the limitations "a third temperature" in line 2 and "a fourth temperature" in line 3. These limitations are indefinite because they imply first and second temperatures, which are not claimed.

***Claim Rejections - 35 USC § 102***

7. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

A person shall be entitled to a patent unless –

(e) the invention was described in (1) an application for patent, published under section 122(b), by another filed in the United States before the invention by the applicant for patent or (2) a patent granted on an application for patent by another filed in the United States before the invention by the applicant for patent, except that an international application filed under the treaty defined in section 351(a) shall have the effects for purposes of this subsection of an application filed in the United States only if the international application designated the United States and was published under Article 21(2) of such treaty in the English language.

8. Claims 1, 2, 5-7, 13, 14, 20-22, 28, and 30 are rejected under 35 U.S.C. 102(e) as being anticipated by Liu et al. (U.S. Pat. No. 6,395,642).

Regarding claim 1, Liu et al. disclose using PVD or CVD to form a barrier layer **120** on a substrate in a vacuum environment, which inherently requires a chamber (col. 5, lines 45-59). A seed layer **130** is then formed on the barrier layer (col. 5, line 60 to col. 6, line 11). In the manufacturing line, the seed layer is oxidized to form a copper oxide layer (passivation layer) **140** (col. 5, line 60 to col. 6, line 11).

Regarding claim 2, the surface is treated in situ in a hydrogen/nitrogen gas environment (col. 6, lines 21-38).

Regarding claim 5, the seed layer **130** is copper (col. 5, line 60 to col. 6, line 11).

Regarding claim 6, the barrier layer **120** is titanium nitride or tungsten nitride (col. 5, lines 45-59).

Regarding claim 7, the first tool is a CVD or PVD tool that is used to form the barrier layer **120** and the seed layer **130** (col. 5, line 45 to col. 6, line 11).

Regarding claim 13, the method comprises placing the substrate structure with the barrier layer **120**, seed layer **130**, and the passivation layer **140** into a contamination removal chamber of an electroplating tool (col. 6, lines 21-38).

Regarding claim 14, the passivation layer **140** is annealed by reduction in a forming gas (col. 6, lines 21-38).

Regarding claims 20 and 21, copper **149** is deposited on a trench and via patterned on the substrate using electrochemical deposition (electroplating) (col. 6, lines 21-38).

Regarding claim 22, Liu et al. teach a method comprising the steps of providing the substrate having barrier layer **120**, a seed layer **130**, and a passivation layer **140** in an electrochemical deposition tool and annealing the substrate in a forming gas to reduce the passivation layer, followed by electrochemically depositing copper **149** in trenches and vias of the substrate (col. 6, lines 21-38).

Regarding claim 28, the method of Liu et al. inherently requires a system comprising a contamination removal chamber for the plasma cleaning to reduce the passivation layer **140** in situ with the electrochemical deposition of the copper **149** (col. 6, lines 21-38).



Claim 30 recite process claims that do not further limit the structure of the system recited in claim 28.

Since Liu et al. teach all of the limitations recited in the instant claims, the reference is deemed to be anticipatory.

9. Claims 1-7, 13, 20, 21 are rejected under 35 U.S.C. 102(e) as being anticipated by Hymes (U.S. Pat. No. 6,423,200).

Regarding claim 1, Hymes teaches the formation of a barrier layer and a seed layer by CVD or PVD, which requires a chamber (col. 7, lines 29-39). Following the deposition of the seed layer, the substrate is exposed to oxygen, forming a passivating oxide layer on the seed layer (col. 7, lines 29-39).

Regarding claims 2 and 4, the substrate is exposed to oxygen to form a metal oxide layer on the metal seed layer (col. 7, lines 29-39).

Regarding claim 3, Hymes also teaches a treatment step using a liquid comprising hydrofluoric acid, citric acid, ammonia, and de-ionized water (col. 2, lines 42-54). The substrate is also treated in a liquid solvent comprising benzotriazole (col. 6, lines 53-65).

Regarding claim 5, the seed layer is copper (col. 4, lines 46-56).

Regarding claim 6, the barrier layer may comprise tantalum nitride (col. 4, lines 33-45).

Regarding claim 7, the tool is a CVD or PVD tool for the deposition of the metal seed layer (col. 7, lines 29-39).

Regarding claim 13, the substrate containing the barrier layer, seed layer, and passivation layer is provided in a contamination removal tool of an electroplating tool (fig. 2A; col. 6, lines 15-31).

Regarding claims 20 and 21, copper is electroplated in trenches and vias of the substrate (col. 7, line 59 to col. 8, line 6).

Since Hymes teaches all of the limitations recited in the instant claims, the reference is deemed to be anticipatory.

### ***Claim Rejections - 35 USC § 103***

10. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

11. Claims 15, 17, 19, 24, and 26 are rejected under 35 U.S.C. 103(a) as being unpatentable over Liu et al. (U.S. Pat. No. 6,395,642), as applied above to claims 1, 2, 5-7, 13, 14, 20-22, 28, and 30, and in view of Nogami et al. (U.S. Pat. No. 6,242,349).

Liu et al. teaches a method and system having the limitations recited in claims 1, 2, 5-7, 13, 14, 20-22, 28, and 30 of the instant invention, as explained above in section 8.

The method of Liu et al. differs from the instant invention because Liu et al. do not teach the following:

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- a. Flowing forming gas for a specified period of time at a seed anneal temperature of about 250°C, as recited in claims 15 and 24.
- b. The specified period of time is about 30 seconds, as recited in claims 17 and 26.
- c. The forming gas comprises about 95% nitrogen and 5% hydrogen, as recited in claim 19.

Regarding claims 15, 17, 19, 24, and 26, the anneal temperature, anneal time, and gas composition are all result effective variables because they depend on the properties of the object being annealed, such as the composition and the thickness, as well as the desired outcome of the annealing process, such as removal of contamination, which is the apparent objective of the instant invention, or formation of a preferred crystal structure. For example, Nogami et al. teach the annealing of a copper seed layer prior to the deposition of a bulk copper layer using a forming gas environment of hydrogen, nitrogen, and argon (hydrogen is the reducing species), wherein the annealing takes place at a temperature between 100°C and 400°C for a time of about 30 seconds to about 30 minutes (col. 5, lines 12-20).

It would have been obvious to one having ordinary skill in the art at the time the invention was made to have modified the method of Liu et al. to use the claimed operating parameters as taught by Nogami et al. to control each of the variables to be optimized for the conditions of the substrate being treated.

12. Claims 16 and 18 are rejected under 35 U.S.C. 103(a) as being unpatentable over Liu et al. (U.S. Pat. No. 6,395,642) in view of Nogami et al. (U.S. Pat. No. 6,242,349), as applied above to claims 15, 17, 19, 24, and 26, and in view of Achuthan et al. (U.S. Pat. No. 6,498,397).

Liu et al. and Nogami et al. describe a method and system having the limitations recited in claims 15, 17, 19, 24, and 26 of the instant invention, as explained above in section 11.

The method of Liu et al. and Nogami et al. differs from the instant invention because they do not teach the following:

- a. Cooling the annealed substrate in forming gas for a specified period of time at a temperature of 15-20°C, as recited in claim 16.
- b. The specified period of time is about 25 seconds, as recited in claim 18.

Regarding claims 16 and 18, Achuthan et al. teach a method of annealing a copper seed layer prior to the deposition of copper, wherein the annealing is carried out at temperatures up to 400°C and is followed by rapid cooling at a rate of more than 1°C per second to form a roughened seed surface to improve the adhesion between the seed layer and the bulk copper layer (col. 5, lines 39-49). The exact temperature and time at which the cooling occurs is a result effective variable that depends on the properties of the substrate being treated.

It would have been obvious to one having ordinary skill in the art at the time the invention was made to have modified the method described by Liu et al. and Nogami et al. to use a step of rapid cooling as taught by Achuthan et al. because rapid cooling

provides greater adhesion between the seed layer and the bulk copper layer. The exact operating conditions, such as time and temperature, would be obvious to one skilled in the art because the operating conditions are dependant upon the properties of the substrate being treated.

13. Claims 23 and 29 are rejected under 35 U.S.C. 103(a) as being unpatentable over Liu et al. (U.S. Pat. No. 6,395,642), as applied above to claims 1, 2, 5-7, 13, 14, 20-22, 28, and 30, and in view of Nogami et al. (U.S. Pat. No. 6,242,349) and Cohen (U.S. Pat. No. 6,027,630).

Liu et al. teaches a method and system having the limitations recited in claims 1, 2, 5-7, 13, 14, 20-22, 28, and 30 of the instant invention, as explained above in section 8.

The method of Liu et al. differs from the instant invention because Liu et al. do not teach the following:

- a. Annealing and depositing a conductive material under vacuum conditions, as recited in claims 23 and 29. (Although claim 29 is an apparatus claim reciting process limitations, the apparatus must be capable of operating under vacuum conditions, which imparts some structural properties to the apparatus.)

Nogami et al. teach the annealing of a seed layer before deposition of bulk copper, wherein the annealing is performed under vacuum conditions (col. 5, lines 12-20). Cohen teaches that electroplating under vacuum conditions degases the

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electroplating solution and avoids pitting of the electroplated layer (col. 15, lines 24-53; col. 17, lines 13-15).

It would have been obvious to one having ordinary skill in the art at the time the invention was made to have modified the method and system of Liu et al. to anneal and deposit under vacuum conditions as taught by Nogami et al. and Cohen because annealing and depositing under vacuum conditions increases the uniformity of the layers.

14. Claims 25 and 27 are rejected under 35 U.S.C. 103(a) as being unpatentable over Liu et al. (U.S. Pat. No. 6,395,642), as applied above to claims 1, 2, 5-7, 13, 14, 20-22, 28, and 30, and in view of Achuthan et al. (U.S. Pat. No. 6,498,397).

Liu et al. teaches a method and system having the limitations recited in claims 1, 2, 5-7, 13, 14, 20-22, 28, and 30 of the instant invention, as explained above in section 8.

The method of Liu et al. differs from the instant invention because Liu et al. do not teach the following:

- a. Cooling the annealed substrate in forming gas for a specified period of time at a temperature of 15-20°C, as recited in claim 25.
- b. The specified period of time is about 25 seconds, as recited in claim 27.

Regarding claims 25 and 27, Achuthan et al. teach a method of annealing a copper seed layer prior to the deposition of copper, wherein the annealing is carried out

at temperatures up to 400°C and is following by rapid cooling at a rate of more than 1°C per second to form a roughened seed surface to improve the adhesion between the seed layer and the bulk copper layer (col. 5, lines 39-49). The exact temperature and time at which the cooling occurs is a result effective variable that depends on the properties of the substrate being treated.

It would have been obvious to one having ordinary skill in the art at the time the invention was made to have modified the method of Liu et al. to use a step of rapid cooling as taught by Achuthan et al. because rapid cooling provides greater adhesion between the seed layer and the bulk copper layer. The exact operating conditions, such as time and temperature, would be obvious to one skilled in the art because the operating conditions are dependant upon the properties of the substrate being treated.

### ***Conclusion***

15. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure.

U.S. Pat. No. 6,319,728 Bhan et al.

U.S. Pat. No. 6,355,153 Uzoh et al.

U.S. Pat. No. 6,461,675 Paranjpe et al.

U.S. Pat. No. 6,554,914 Rozbicki et al.

U.S. Pat. No. 6,565,729 Chen et al.

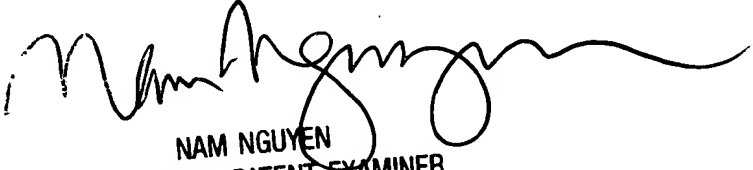
US 2002/0076929 A1 Lu et al.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Brian L. Mutschler whose telephone number is (571) 272-1341. The examiner can normally be reached on Monday-Friday from 7:30am to 4:00pm.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Nam Nguyen can be reached on (571) 272-1342. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

blm  
March 25, 2004



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